

On the Security of “an efficient and complete remote user authentication scheme”

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Abstract

Recently, Liaw et al. proposed a remote user authentication scheme using smart cards. Their scheme has claimed a number of features e.g. mutual authentication, no clock synchronization, no verifier table, flexible user password change, etc. We show that Liaw et al.’s scheme is completely insecure. By intercepting a valid login message in Liaw et al.’s scheme, any unregistered user or adversary can easily login to the remote system and establish a session key.

Keywords: Password, Authentication, Smart cards, Remote system.

1 Introduction

Remote system authentication is a process by which a remote system gains confidence about the identity (or login request) of the communicating partner. Since the Lamport’s scheme [1], several remote user authentication schemes and improvements have been proposed with and without smart cards. Recently, Liaw et al. [2] proposed a remote user authentication scheme using smart cards. Their scheme has claimed a number of features e.g. mutual authentication, no clock synchronization, no verifier table, flexible user password change, etc. We show that Liaw et al.’s scheme is completely insecure. Any unregistered user can easily login to the remote system and establish a session key.

2 The Liaw et al.’s scheme

The scheme consists of five phases: registration, login, verification, session and password change.

Registration phase: A new user U_i submits identity ID_i and password PW_i to the remote system for registration. The remote system computes U_i ’s secret information $v_i = h(ID_i, x)$ and $e_i = v_i \oplus PW_i$, where x is a secret key maintained by the remote system and $h(\cdot)$ is a secure one-way hash function. Then the remote system writes $h(\cdot)$ and e_i into the memory of a smart card and issues the card to U_i .

Login phase: When U_i wants to log into the remote system, he/she inserts the smart card into the terminal and enters ID_i and PW_i . The smart card then performs the following operations:

L1. Generate a random nonce N_i and compute $C_i = h(e_i \oplus PW_i, N_i)$.

L2. Send the login message $\langle ID_i, C_i, N_i \rangle$ to the remote system.

Verification phase: To check the authenticity of $\langle ID_i, C_i, N_i \rangle$, the remote system checks the validity of ID_i . If ID_i is valid, computes $v'_i = h(ID_i, x)$ and checks whether $C_i = h(v'_i, N_i)$. Then generates a random nonce N_s , encrypts the message $M = E_{v'_i}(N_i, N_s)$ and sends it back to the card.

The smart card decrypts the message $D_{e_i \oplus PW_i}(M)$ and gets (N'_i, N'_s) . Then verifies whether $N'_i = N_i$ and $N'_s = N_s$ ¹. If these checks hold valid, the mutual authentication is done.

Session phase: This phase involves two public parameters q and α where q is a large prime number and α is a primitive element mod q . The phase works as follows:

S1. The remote system computes $S_i = \alpha^{N_s} \bmod q$ and sends S_i to the smart card. The smart card computes $W_i = \alpha^{N_i} \bmod q$ and sends W_i to the remote system.

S2. The remote system computes $K_s = (W_i)^{N_s} \bmod q$ and, the smart card computes $K_u = (S_i)^{N_i} \bmod q$. It is easy to see that $K_s = K_u$. Then, the card and the remote system exchange the data using the session key and e_i .

Password change phase: With this phase U_i can change his/her PW_i by the following steps:

S1. Calculate $e'_i = e_i \oplus PW_i \oplus PW'_i$.

S2. Update e_i on the memory of smart card to set e'_i .

3 Security Weaknesses

Weakness of Authentication phase: The authentication phase suffers from the replay attacks. The authenticity of the login request is not checked at all. The adversary \mathcal{A} (or any unregistered user) intercepts a valid login request, say $\langle ID_i, C_i, N_i \rangle$. Later \mathcal{A} sends $\langle ID_i, C_i, N_i \rangle$ to the remote system, as a login request. To validate $\langle ID_i, C_i, N_i \rangle$, the remote system does the following:

1. Check the validity of ID_i . This holds true, because the adversary sends ID_i , intercepted from a valid login request.
2. Compute $v'_i = h(ID_i, x)$ and check whether $C_i = h(v'_i, N_i)$. This check also passes successfully, because there is no record at the server side whether N_i was used in some previous login message. Therefore the server is unable to detect whether the C_i is coming from a legitimate user or from an adversary. Now we see the security strength of the mutual authentication.
3. The remote system generates a nonce N_s^* and encrypts the message $M = E_{v'_i}(N_i, N_s^*)$, then sends $\langle M \rangle$ back to the communicating party (assumes logged in entity is a legitimate user).

¹It is noted that the verification of $N'_s = N_s$ cannot be examined because the smart card does not have information about N_s

4. \mathcal{A} will not do anything, simply sends a valid signal by saying that the server authenticity is done and then, \mathcal{A} gains the access to the remote system. Therefore, ultimately there is no user or server authenticity checks at all.

Weakness of Session phase: Although Liaw et al.'s scheme used Diffie-Hellman [3] key exchange protocol for session key establishment; however, they did not consider the risk of Diffie-Hellman's protocol (i.e., man-in-the-middle attack) while establishing the user and server common session key. Let us examine the weakness of the session phase.

1. The remote system computes $S_i = \alpha^{N_s^*} \bmod q$ and sends S_i to the communicating party. \mathcal{A} (who already passes the authentication phase and gains the access to the remote system) computes $W_i = \alpha^{N_i} \bmod q$ and sends W_i to the remote system.
2. The remote system computes $K_s = (W_i)^{N_s^*} \bmod q$ and \mathcal{A} computes $K_a = (S_i)^{N_i} \bmod q$. It is easy to see that $K_s = K_a$.

In fact, all the parameters N_i, S_i, W_i, α, q are public, thereby any one can compute the session key. Once the session key is established then the remote system and \mathcal{A} exchange data in an encrypted manner, where e_i acts as the encryption key. Firstly, the remote system does not know e_i . Secondly, the session key never serve the purpose of the transaction privacy, instead it is just xor-ed with the message and e_i is used for transaction privacy, which is not the actual scenario in the practical applications.

Weakness of Password change phase: There is no verification of the entered password. This effectively makes the smart card useless. Suppose U_i enters his password which is actually misspelled or incorrect, that is, instead of PW_i he/she enters PW . However, the smart card takes the wrong password PW and asks for a new password. Now, U_i enters new password PW'_i . The smart card updates old e_i by the new e'_i where $e'_i = e_i \oplus PW \oplus PW'_i = h(ID_i, x) \oplus PW_i \oplus PW \oplus PW'_i$. In the next login time, U_i cannot login to the remote system, because the verification of C_i fails. In another scenario, if U_i 's smart card is lost or stolen, then the party who got the smart card, would try to login and enters some random password, which leads to block the card, as there is no provision of checking the entered password.

4 Conclusion

We have shown the security weaknesses of the Liaw et al.'s scheme. The design of the Liaw et al.'s scheme is so weak that any one can login to the remote system by just intercepting a valid login message.

References

- [1] L. Lamport, Password authentication with insecure communication. *Communications of the ACM* **24** 770–772 (1981).
- [2] H. -T. Liaw, J. -F. Lin and W. -C. Wu, An efficient and complete remote user authentication scheme using smart cards. *Mathematical and Computer Modelling*, Elsevier **44** 223–228 (2006).

- [3] W. Diffie and M. E. Hellman, New directions in cryptography. *IEEE Transactions on Information Theory* **22** 644–654 (1976).